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The geneticist in the garage

Citizen scientists are setting up their own gene laboratories in the hope of inventing new and useful organisms. But are they a danger to us all?

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Meredith Patterson at work in her home lab. Photograph: Noah Berger/AP

The following correction was printed in the Guardian's Corrections and clarifications column, Monday March 23 2009

We said in the report below that the BioWeatherMap project had been nicknamed Google Flu. To clarify, there is no connection between DIYbio, the organisation that runs BioWeatherMap, and Google

Meredith Patterson is not your typical genetic scientist. Her laboratory is based in the dining room of her San Francisco apartment. She uses a plastic salad spinner as a centrifuge and Ziploc plastic bags as airtight containers for her samples. But the genetically modified organism (GMO) she is attempting to create on a budget of less than $500 (£350) could provide a breakthrough in food safety.

The 31-year-old ex-computer programmer and now biohacker is working on modifying jellyfish genes and adding them to yoghurt to detect the toxic chemical melamine, which was found in baby milk in China last year after causing a number of deaths, and kidney damage to thousands of infants. Her idea is to engineer yoghurt so that in the presence of the toxin it turns fluorescent green, warning the producer that the food is contaminated. If her experiment is successful, she will release the design into the public domain.

"I haven't had a huge amount of success so far," says Patterson. "But science is often about failing until you get it right." She has decided to invest in an electroporator she found on eBay for $150, which should speed things up. "It's actually not that hard. It's a bit like making yoghurt. And if there's material left over from the experiment, I can eat it," she says.

Evolving community

Patterson is just one of dozens of citizen scientists setting up their own gene laboratories in the hope of inventing new and useful organisms. A community is evolving to take advantage of low-cost, off-the-shelf genetic parts and increasing knowledge in biological engineering. International competitions such as the International Genetically Engineered Machine (iGEM) and io9 Mad Science contest have already produced a number of stars, with practical innovations in medicine, agriculture and biocomputing.

However, Helen Wallace of GeneWatch in the UK thinks biohacking could be dangerous. "It is increasingly easy to order genes by mail," she says. "Something like smallpox is hard to get, but there are other organisms that could become harmful. If you change a living organism's properties, you could also change its interactions with the environment or the human body." She adds: "Scientists are notorious for not seeing the unintended consequences."

Reshma Shetty is part of the team behind Ginkgo Bioworks, a Massachusetts-based company aiming to make DIY biotechnology a reality. She says: "Nowadays, biotechnology is like a medieval guild. Firstly, you have to get a PhD, but if you want to practise you then need venture capital, otherwise you don't have the tools." Ginkgo aims to make the process easier by offering off-the-shelf biological components and a third-party service for rapid prototyping. "This will take power away from patent owners like Monsanto and pave the way for more people to have a positive impact," she says.

Ginkgo has already constructed GMOs that release the odour of bananas, turn red or glow in the dark, and is developing a host of new organisms that will all be in the public domain. "They're not harmful pathogens," she says. "Complex organisms make use of the same components to do all this incredible stuff without any harmful chemicals ... In 10 years, all sorts of new stuff will have been done."

Jim Thomas, of the environmental thinktank ETC Group, says: "The risk is we have limited knowledge of how these things work. GM crops have out-crossed [bred with non-GM plants] after we were told they wouldn't. GM biofuels have also been shown to damage surrounding food crops. Where is the oversight?"

MacKenzie Cowell is a founding member of Boston-based DIYbio, which provides tools and advice to biohackers. In May they will co-ordinate the first "Flash Lab", sending out 1,000 volunteers to take swabs from pedestrian crossing buttons around Boston. The data will be analysed to produce a BioWeatherMap of bacteria roaming the city.

Outbreak

"We think we'll pick up all sorts of surprising stuff," says Cowell. "I was sick for three days with the symptoms of salmonella last year, before finding out there had been an outbreak in New York where I was staying." This inspired him to start the project, which has been nicknamed "Google Flu". "We hope to get out and do these once a month," he says, "but it could happen far more frequently."

Benefits may come from increased access and transparency in science, but sometimes the authorities have difficulty recognising it. In 2004, the art professor Steve Kurtz was arrested as a suspected bioterrorist because Petri dishes with bacteria in them were found at his home in New York state, after his wife had died of a heart attack. Last year Victor Deeb, a retired chemist, had his basement laboratory taken apart by US environmental officials after a fire in the apartment upstairs. He was trying to make safe surface coatings for food containers using chemicals less hazardous than those found in household cleaners.

In Britain, regulations are far stricter. Chris French, a lecturer at Edinburgh University and local biological safety officer, says: "There's very little that can be done at a home address ... GMOs are very strictly regulated by the Health and Safety Executive – and for sound reasons. Working with living things which can potentially escape and grow offers potential hazards."

Surgical tasks

This hasn't stopped UK university teams from developing a host of useful biological innovations over the last few years. One of the winners of last year's iGEM competition was Bristol University's Bacto-Builders project, using teams of *E. coli* bacteria to perform surgical tasks that single organisms would find impossible. Its project is moving forward in collaboration with the TiGEM genetics laboratory in Italy.

"We are in the nascent stages of some kind of DIY biotechnology network in the UK," says Kim de Mora, a biology PhD student at Edinburgh University. "But ... it's going to be hard to set up a garage industry because of the regulations."

De Mora was part of a team that developed an arsenic detector for contaminated water in Bangladesh. *E. coli* bacteria were modified using BioBrick components to produce a warning signal in the presence of arsenic. If their working prototype is developed into a commercial product, it will be much cheaper than existing technologies. "The real potential of biotechnology will explode in the UK after people are given access at home," predicts De Mora.

In the meantime, iGEM's global Registry of Standard Biological Parts is doubling the size of its catalogue of organic building blocks every year. Within the next decade, millions upon millions of new synthetic organisms are sure to be created. The question is: who will be allowed to create them? At the moment, it looks like the future of biotechnology could be more diverse and volatile than anyone had imagined.